INDOOR AIR QUALITY ASSESSMENT

Wayland Town Hall
41 Cochituate Street
Wayland, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

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Background/Introduction

At the request of Steve Calichman, Director of Public Health for the Wayland Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Wayland Town Hall (WTH), Wayland, MA. The indoor air quality inspection was prompted by concerns about lingering odors following flooding from the building's sprinkler system.

On May 13, 2003, a visit was made to the WTH by Cory Holmes an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program, to conduct an indoor air quality assessment. Mr. Holmes was accompanied by John Winkleman, Head Custodian and Mr. Calichman for portions of the assessment.

The WTH is a multi-story brick building originally constructed as the Wayland High School in the 1940's. The building was renovated and converted to town offices in the 1980's. The building has a peaked shingled roof. Windows are openable throughout the building. The building contains town offices, public meeting rooms, the Wayland Police Department headquarters and a private day care facility.

In January 2003, the building reportedly experienced extensive water damage to ceilings, floors and walls caused by flooding resulting from the freezing of sprinkler pipes in the attic (see Picture 1). Service Master Inc. was hired to dry out carpeting and clean/disinfect areas of water damage. Service Master Inc. dried carpeting by fanning and heating carpeted areas. The company also drilled holes in walls to dry/ventilate wall cavities.

Employees were relocated from the building for several months during remediation of the building. As part of this remediation, carpeting, ceiling tile systems and wood flooring materials were replaced (see Picture 2). Wayland town officials also sampled water in the crawlspace since propylene glycol was used as an antifreeze agent in the sprinkler system that ruptured. This sampling and analysis test was done to determine appropriate methods for disposal of crawlspace water.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Systems, Inc, Photo Ionization Detector (PID). Outdoor background TVOC measurements were taken for comparison to indoor levels. Water content of gypsum wallboard (GW) was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe.

Results

The WTH has an employee population of approximately 50-75 and is visited by approximately 75-100 individuals daily. The tests were taken during normal operations. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm (parts per million) in two of twelve areas surveyed, indicating adequate ventilation in most areas of the building. However, during the assessment the mechanical ventilation system was not operating. The sole source of fresh air in the building during the assessment was air penetrating through open windows and/or the periodic opening of exterior doors.

Fresh, heated air is supplied by air-handling units (AHUs) located in the attic. Ventilation is delivered to occupied areas via ceiling-mounted air diffusers (see Picture 3) connected to ductwork that runs back to AHUs. Return/exhaust air is drawn into ceiling vents and ducted back to AHUs. Prior to the assessment, town maintenance personnel deactivated AHUs reportedly to prevent the distribution of foul odors believed to be emanating from the crawlspace. Therefore during the assessment, no mechanical means of ventilation was being provided.

Ductwork in the attic is constructed of fiberboard material that is held together by duct tape. In many instances breaches were observed in the ductwork where it had become damaged or duct tape was failing (see Picture 6). These breaches can allow heated or cooled air to move into the attic space, creating an imbalance in the ventilation system. This imbalance can lead to temperature/comfort complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation, the mechanical supply and exhaust systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room

(SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please refer to Appendix I.

Temperature readings ranged from 66^{o} F to 73^{o} F, which were below the BEHA recommended comfort guidelines in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Temperature control is difficult without the ventilation systems functioning (e.g. deactivation of AHUs).

The relative humidity measured in the building ranged from 37 to 54 percent, which was slightly below the BEHA recommended comfort range in some areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Of note was the relative humidity measured in first floor restrooms. These relative humidity measurements exceeded outdoor measurements (+ 12 to 14%). It is important to note that these restrooms are located directly over the crawlspace. The increase in relative humidity is most likely a result of the restroom exhaust system drawing moisture from the crawlspace through available pathways (e.g. utility holes) (see Microbial/Moisture Concerns).

Microbial/Moisture Concerns

As previously mentioned, the building experienced water damage due to flooding in January 2003. In order for building materials to support mold growth, a source of water exposure is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. GW with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of GW with increased moisture levels can also provide clues concerning the source of mold growth. In an effort to ascertain moisture content of GW, measurements were taken in areas directly impacted by water damage as well as in a number of non-effected areas for comparison (see Tables).

Water content of GW was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe. The Delmhorst probe is equipped with three lights as visual aids to determine moisture level. Readings, which activate the green light, indicate a sufficiently dry moisture level (0 - 0.5%), those that activate the yellow light indicate borderline conditions (0.5 – 1.0%) and those that activate the red light indicate elevated moisture content (> 1%). The probe was inserted into the surface of GW along the wallboard at various heights. No elevated moisture levels were recorded in any building materials measured. Visual inspection of walls, ceilings and carpeting suggested no obvious residual water damage resulted from the sprinkler release. These results indicate that, at the time of this assessment, the building materials were not moistened and microbial growth would be limited due to a lack of moisture.

Pungent odors were reported by a number of building occupants. The most prominent odors were reported to be in the vicinity of the first floor restrooms. Mr. Calichman opened several access plates to observe conditions in the crawlspace. Approximately 8 to 10 inches of standing water was observed in the crawlspace (see Picture 7). Strong musty odors and a clear, white sheen was seen covering the surface of the water. Standing water can become stagnant, which can lead to bacterial or other microbial growth that can be a source of unpleasant odors. Fiberglass pipe insulation was severely water damaged and showed signs of possible mold growth (see Picture 8). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy materials is not recommended.

BEHA staff detected strong odors in the vicinity of the first floor restrooms. A utility hole was observed in the floor of the men's room that was open to the crawlspace (see Picture 9). A prominent draft was noted from the hole. Open utility holes, spaces around access plates or any other breaches between the crawlspace and the first floor can provide pathways for odors to migrate into occupied areas.

The age of and extent of water damaged materials suggests that crawlspace flooding in the WTH has likely been a chronic problem. No obvious interior moisture sources were noted. Several other likely sources of water, in addition to the sprinkler system failure, however, were identified and largely relate to penetration through the foundation/walls. Several potential sources of water penetration exist:

- Missing/damaged bricks (see Picture 10), holes and spaces in exterior walls of the building.
- Small trees/stumps, and other plants were growing in the tarmac/exterior wall junction. The growth of roots/plants against the foundation/exterior walls of the building can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level.
- The gutter/downspout system along the roof was either missing or in disrepair (see Picture 11). Gutters and downspouts are designed to direct rainwater away from the base of the exterior walls. In some cases the gutter/downspout system empties water directly against the foundation or into the crawlspace (see Pictures 12 & 13). These conditions can undermine the integrity of the building envelope and provide a means of water entry

into the building through foundation concrete and masonry by capillary action (Lstiburek & Brennan, 2001).

- The original underground drainage system appears to have been abandoned and rerouted back into the building (see Picture 14). Town officials had no information concerning the path of the drainage system or when these alterations were made. Mr. Winkleman informed BEHA staff that the town was in the bidding process contracting out work for the building's drainage system.

A number of areas had water-damaged building materials (e.g. stained ceiling tiles, peeling paint) (see Pictures 2, 15 & 16) that were unrelated to the sprinkler system rupture. These water damaged building materials are evidence of roof or plumbing leaks. Active leaks were reported in several areas of the building and a number of buckets were observed in the attic, apparently stationed to collect rainwater (see Picture 17). Water-damaged ceiling tiles can provide a source of mold and mildew and should be replaced after a water leak is repaired.

Other Concerns

As discussed, Wayland Health Officials had the water tested due to the presence of the chemical antifreeze agents (e.g. propylene glycol) in the sprinkler system that ruptured. The Food and Drug Administration (FDA) has classified propylene glycol as "generally recognized as safe" and can be used in products such as flavorings, drugs and cosmetics. According to the Agency for Toxic Substances and Disease Registry (ATSDR), both ethylene glycol and propylene glycol are unlikely to exist in large amounts in air and both compounds break down within several days to a week in water and soil (ATSDR, 1997). Several weeks after the assessment Mr. Calichman reported water samples contained 120 parts per billion (ppb) of acetone, which is most likely a breakdown product of these products. The presence of acetone may also be a contributing factor in the intermittent odors reported by building occupants. TVOC readings within the building were found to be equal to background levels measured outdoors in all occupied areas surveyed.

Due to relatively safe classification of propylene glycol and its rapid breakdown in water and soil, health effects, if any, would be expected to be short-term irritant effects. Therefore, individuals at the WTH are not likely to experience chronic health effects due to short duration of exposure to the constituents of this product.

Finally, the return vent located under the stage in the gymnasium/auditorium contained 1" to 2" of accumulated dust and debris (see Picture 18). This system was not operating during the assessment. If exhaust vents are not functioning, backdrafting can occur, which can aerosolize dust particles. In addition, these materials can accumulate on flat surfaces and subsequently be re-aerosolized.

Conclusions/Recommendations

The conditions found in the WTH present a number of issues that require a series of remedial steps. For this reason a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address overall conditions contributing to the indoor air quality concerns.

In view of the findings at the time of this assessment, the following **short-term** recommendations are made:

1. Seal utility holes and other potential pathways to eliminate pollutant paths of migration from the crawlspace to the first floor.
2. Continue with plans to pump water from crawlspace in a manner consistent with Massachusetts Department of Environmental Protection (MDEP) regulations.
3. Consider contacting the town's HVAC contractor concerning the reactivation of the buildings HVAC system. If possible create a slight positive pressure in the first floor, relative to the crawlspace pressure.
4. Work with the HVAC engineer to determine the most appropriate method to provide active mechanical exhaust ventilation to place the crawlspace under negative pressure. Placing the crawlspace under negative pressure will reverse air penetration into occupied spaces.
5. To maximize air exchange, the BEHA recommends that all ventilation systems that are operable throughout the building (e.g. gym/auditorium, preschool classrooms) operate continuously during periods of school occupancy independent of thermostat control. Set thermostats to fan "on" position to provide a constant source of ventilation.
6. In order to improve indoor air quality, an increase in the percentage of fresh air supply into the HVAC system may be necessary.
7. Inspect and seal all breaches in the fiberboard ductwork in the attic to gain temperature control and reduce heating/cooling loss.
8. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to

minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

10. Work with a roofing contractor to identify and repair leaks. Replace any water-stained ceiling tiles and building materials. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
11. Continue with plans to hire a contractor to repair the downspout and gutter systems that direct water away from the building.
12. Seal holes/breaches in the building envelope to prevent water penetration and pests.
13. Change filters in air handling equipment as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter.
14. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

The following **long-term** measures should be considered:

1. Explore options for providing a barrier between the dirt floor and crawl space. Consider consulting a building engineer, hydrogeologist and/or an environmental engineering firm about possible options to eliminate water accumulation in the crawlspace. Once water is removed, replace water damaged insulation. Consider replacing with a waterproof insulating material.

2. To prevent moisture penetration into the crawlspace, the following actions should be considered:

   a. Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek and Brennan, 2001).

   b. Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek and Brennan, 2001).

   c. Move foliage to no less than five feet from the foundation.

3. Remove and replace any mold contaminated/water damaged building materials in the crawlspace. This measure will remove actively growing mold colonies that may be present. Remove mold contaminated materials in a manner consistent with recommendations found in *Mold Remediation in Schools and Commercial Buildings* published by the US Environmental Protection Agency (US EPA) (US EPA, 2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.

References

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Picture 1

Portion of the Sprinkler System in the Attic Where Leak Occurred

Picture 2

Portions of the Wooden Floor in the Attic Replaced (Light Colored)

Picture 3

Ceiling-Mounted Air Diffuser

Picture 4

Breaches in the Integrity of Fiberboard Ductwork in Attic

Picture 5

Items Stored on and around Fiberboard Ductwork in Attic

Picture 6

Breaches in the Fiberboard Ductwork in the Attic

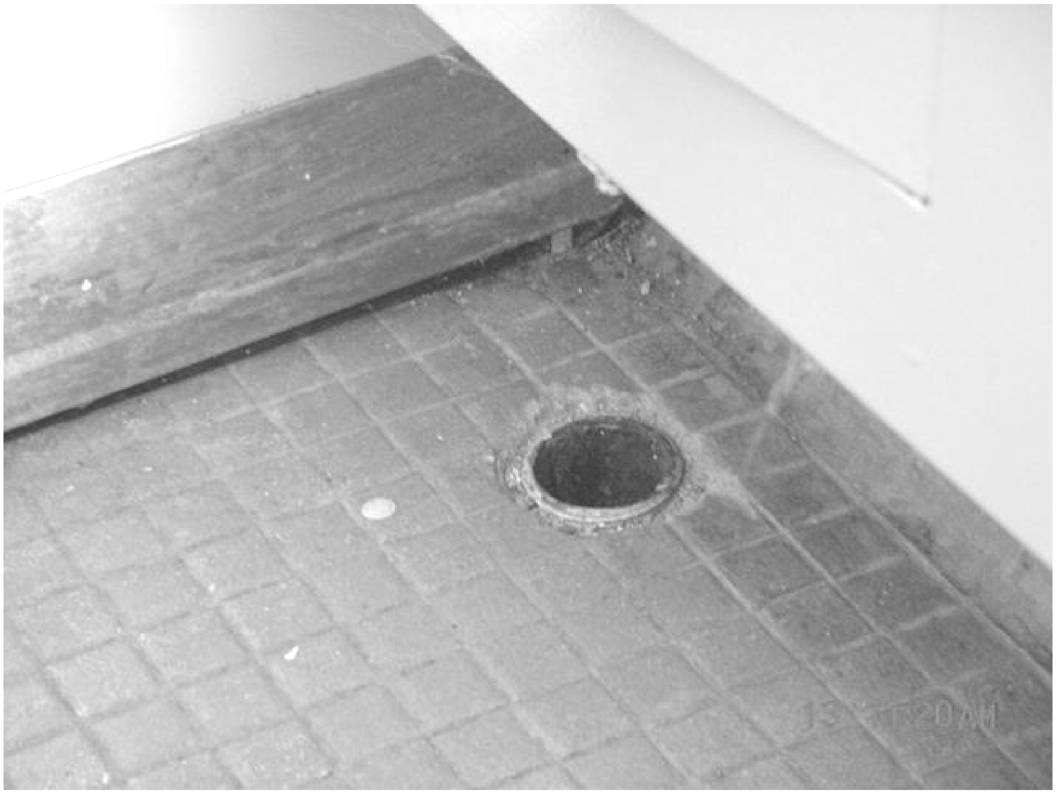
Picture 7

Standing Water in Crawlspace

Picture 8

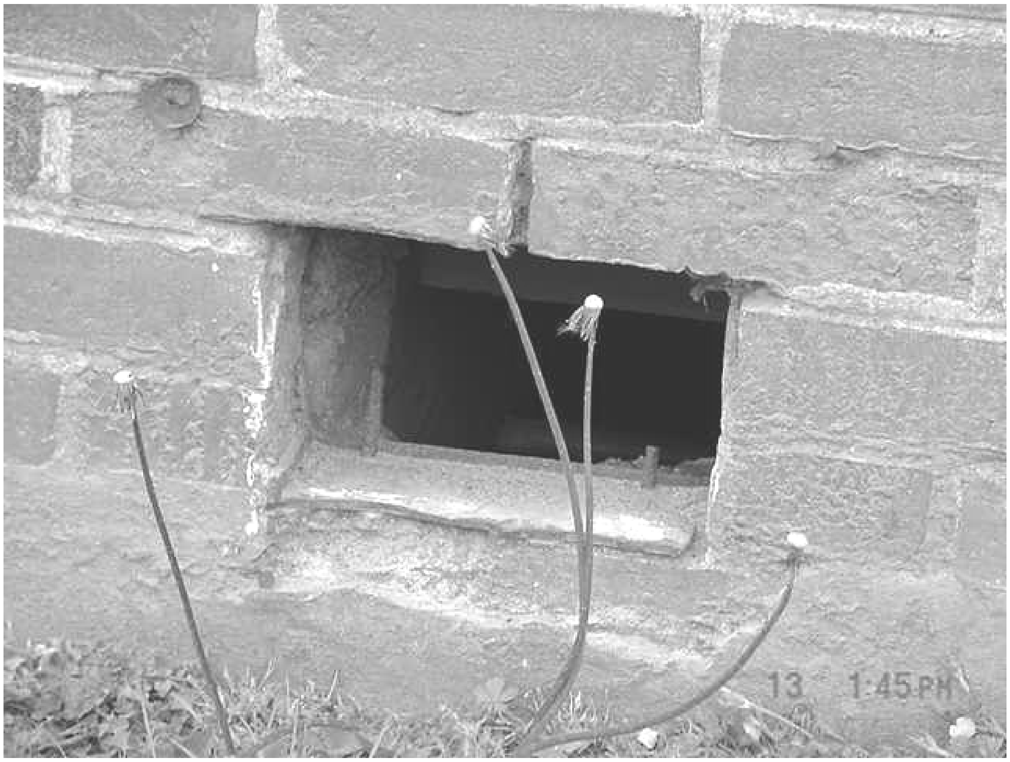
Water Damaged Pipe Insulation

Picture 9



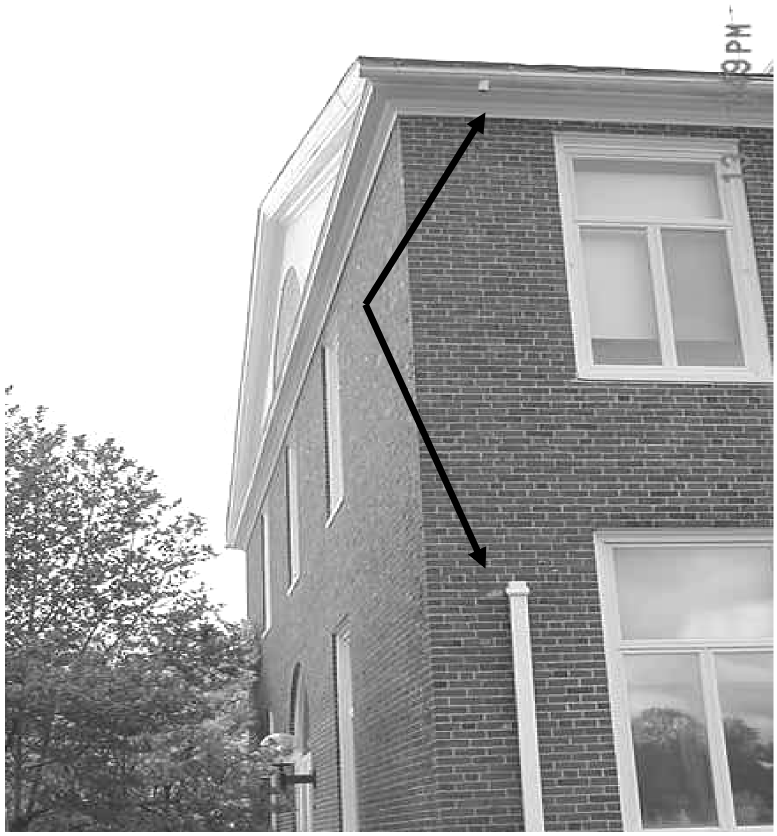
Open Utility Hole in First Floor Men's Room

Picture 10



Hole in Building Envelope Near Foundation of Building

Picture 11



Damaged/Missing Gutter/Downspout System

Picture 12

Gutter/Downspout System Emptying Water into Crawlspace Grate

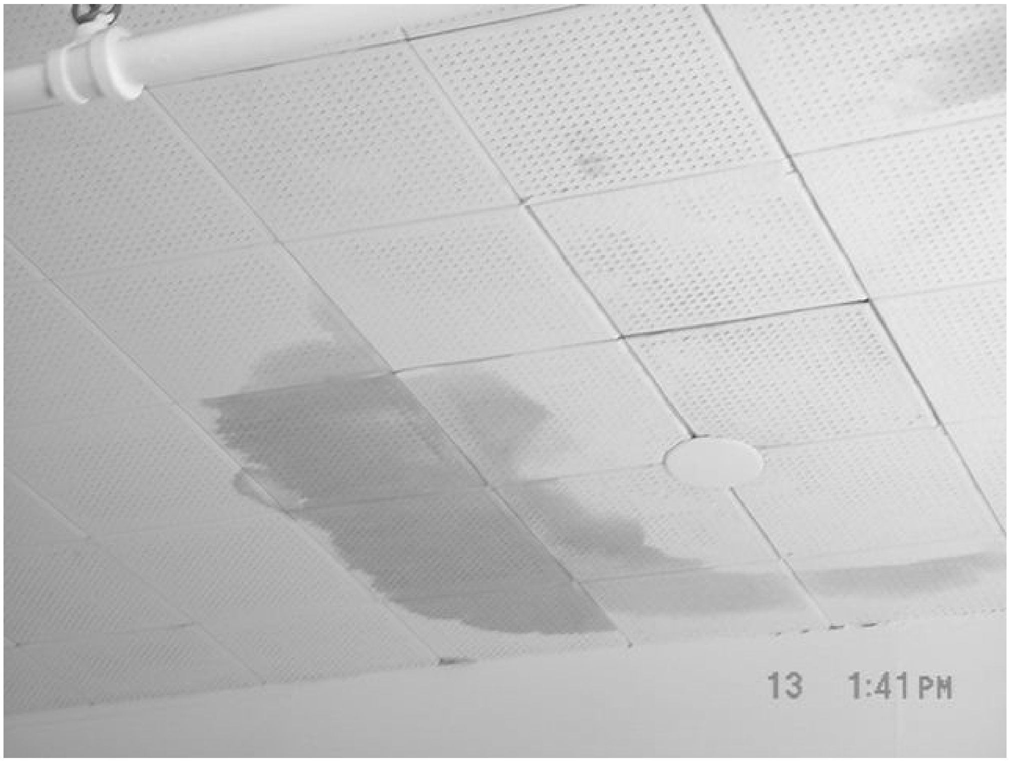
Picture 13

Gutter/Downspout Emptying Water Directly Against the Foundation, Note Depression Pit Downspout

Picture 14

Current Drainage System Re-routed through the Brick Into the Interior of the Building, Original Underground Drain Sealed below

Picture 15



Stained-Interlocking Ceiling Tiles

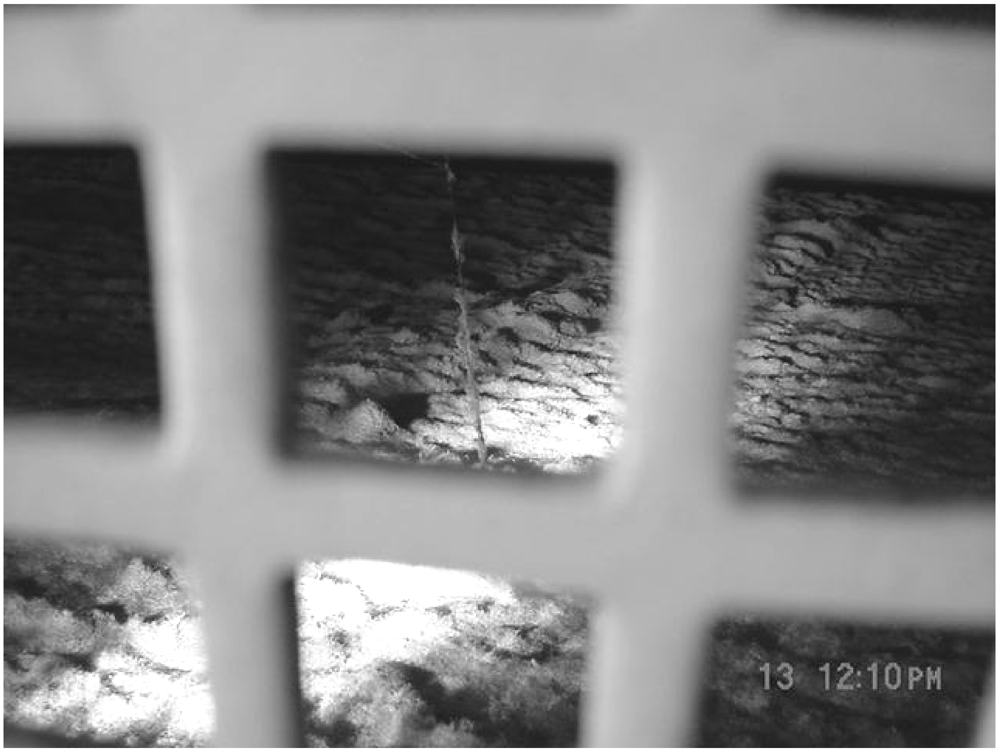
Picture 16

Peeling/Water-Damaged Paint

Picture 17

Buckets (Partially Full) in the Attic to Collect Rainwater

Picture 18



Accumulated Dirt, Dust and Debris in Return Vent under Stage in Gymnasium Auditorium

TABLE 1

Indoor Air Test Results –Wayland Town Hall, Wayland Massachusetts May 13, 2003

Location	Carbon Dioxide (*ppm)	TVOCs (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Background	356	0.0	67	42					Cloudy, intermittent sunshine, scattered showers
Crawlspace									6 – 8" standing water, musty/ mold odor, film on surf, exhaust fan copy room running
Men's Room	685	0.0	66	54		Y	Y	Y	Open utility pipe into crawlspace – draft, musty odors exhaust week
Women's Room	677	*1.3-1.8	66	56	0	N	Y	Y	Deodorizer odors
Attic									Supply capped/off, wood flooring & insulation replaced
Back Hallway Way Children's Way	619	0.0	71	43	4	N	N	N	CT water damage wall along roof seem, GW moisture readings 0.1-0.2 (dry)
Giraffe Class	589	0.0	7	41	10	Y	Y	Y	
1st Floor Hallway Children's Way	788	0.0	73	43	0	N	N	N	CT's
Bunny Room	1246	0.0	73	45	12	Y	Y	Y	CT's along beam

*** ppm = parts per million parts of air**
CT – water damaged ceiling tiles
GW – gypsum wallboard
WD – water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Location	Carbon Dioxide (*ppm)	TVOCs (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Storage Hallway OT/PT									1 CT
Gym	431	0.0	70	40	1	N	Y	Y	Under stage 1” dirt/dust and debris – exhaust vent
Health Director’s Office	696	0.0	72	43	0	N	N	N	GW moisture readings 0.0-0.2 (dry)
BOH Main Area	852	0.0	72	42	3	Y	Y	Y	GW moisture readings 0.0-0.2 (dry)
Surveyor’s Office	770	0.0	72	43	0	Y	Y	Y	GW moisture readings 0.0-0.3 (dry)
Conservation Office	672	0.0	73	37	4	Y	Y	Y	GW moisture readings 0.1-0.2 (dry)
2nd Floor School Department	475	0.0	73	37	4	Y	Y	Y	
Attic									HVAC breaches in fiberboard duct work – evidence of roof leaks- buckets, items stored on/around HVAC equipment
Accounting						Y	Y	Y	CTs

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